RAW MATERIALS

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DEPOSITS OF CLAY IN RUSSIA

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The data of geological expeditions prospecting argillaceous materials in various parts of Russia are summarized. The data on the chemical composition and the main technological (ceramic) characteristics of currently operated clay deposits in Russia are analyzed. A conclusion is made of the expedience of testing refractory clays from the Latnenskoe and Troshkovskoe deposit in the insulator industry. The expedience of continuing research on white-burning refractory clays in the eastern part of the Leningrad Region is demonstrated.

The problem of using domestic raw materials in industry, in particular, in porcelain production, is topical now, considering that since the breakup of the USSR, the majority of raw material resources are situated outside Russia. The situation with argillaceous materials is the most complicated, since all insulator works and household porcelain factories use Ukrainian clay from the Novoraiskoe deposit (TU U 322-7-00190503-145–98).

Let us consider the main clay deposits in Russia.

The state inventory of refractory clays includes 52 deposits, among which 18 are operating. The remaining deposits have been prospected but are not intended for mining.

NORTH-WESTERN REGION OF RUSSIA

The North-Western Region includes 15 deposits, of which 14 are located in the Borovichsko-Lyubytinskoe District of the Novgorod Region.

Borovichsko-Lyubytinskoe group of deposits

The clay deposits in the Borovichi – Lyubytino District are the best studied with respect to their chemical composition and ceramic properties, the bedding conditions, and the quantities. The deposits of this district were once described by G. A. Dvinskii [1], and an analysis of the chemical compositions of these clays was performed by P. A. Zemyatchenskii [2].

Some deposits in this group are already exhausted (Artem and Volginskoe), other are classified as prospected reserve deposits (Balakovskoe, Sherokhovichi, Raitzkoe, etc.), and some are classified as not intended for industrial operation (Khoromy).

The refractory clays are represented by plastic, kaolinic, or semi-kaolinic varieties bedded nearly horizontally in strata. Clays of the same lithologic variety prevail, which provides for a simple structure of the beds, occasionally complicated by interlayers of other varieties and sands.

The chemical composition of clays in the individual deposits ranges within the following limits (wt.%, in calcined material): 40.56 – 70.00 SiO_2, 9.46 – 56.04 ($Al_2O_3 + TiO_2$), 0.30 – 3.62 Fe_2O_3, 2.25 – 29.27 calcination loss. The refractoriness of the clay is 1350 – 1750°C.

According to the content of oxides ($Al_2O_3 + TiO_2$), the clays are subdivided into highly basic, basic, and semi-acid. The distribution of highly basic and basic clays is random. In calculations, the distribution of the clays among the above types was statistically determined. Semi-acid clays in most deposits are insignificantly extended.

The operating deposits are: Brynkino Ust'e, Shibotovskoe, Okladnevskoe, Malinovetskoe. About 600 thousand tons of clay are mined per year.

The clay reserves in these deposits exceed 20 million tons, which is sufficient for 25 years of operation of the mining company.

Brynkino Ust'ye deposit

This deposit is located in the Borovichi District, 2 – 3 km south-west from the town of Borovichi, on the left shore of the Krupna River, a tributary to the Msta River.

The clay is bedded in two layers: the upper one contains plastic clay, and the lower one has kaolinic clay. The average thickness of the plastic clay is 1.2 – 1.4 m, and that of the

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TABLE 1

Clay	Weight content, %				
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	calcination loss
BLP-1	50.00 – 54.00	37.50	1.50 – 3.50	2.05	12.50 – 14.00
BLP-2	54.00 – 60.00	32.50	2.00 – 3.00	2.05	11.50 – 13.50
BLP-3	56.00 – 62.00	28.00	2.00 – 3.50	2.00	9.70 – 13.00

TABLE 2

Clay	Total moisture content, %	Shrinkage, %		Water absorption at 1300°C, %	Refractoriness, °C
		air	total		
BLP-1	26.3 – 30.0	6.0 – 8.5	15.0 – 20.0	0.3 – 1.5	1710 – 1760
BLP-2	26.0 – 30.0	7.0 – 2.5	13.0 – 17.0	0.5 – 2.5	1650 – 1710
BLP-3	25.0 – 30.0	7.0 – 10.0	12.0 – 16.0	0.5 – 6.0	1580 – 1730

TABLE 3

Clay	Weight content, %			Refractoriness, °C
	Al_2O_3	Fe_2O_3	calcination loss	
BLP-1	35.84 – 40.88	2.57 – 2.89	10.98 – 13.26	1710
BLP-2	36.60 – 36.84	3.02 – 3.66	11.88 – 13.62	1710 – 1690
BLP-3	29.84 – 38.26	3.35 – 5.00	10.02 – 14.20	1630 – 1650

kaolinic clay is 1.3 – 1.5 m. The depth of occurrence is 25 – 40 m.

The plastic clay based on its mineral composition belongs to the kaolinite-hydromica group and is highly disperse.

The chemical composition of the plastic clay (wt.% in calcined material) is 20.0 – 44.0 ($Al_2O_3 + TiO_2$), 1.3 – 1.7 Fe_2O_3, 8.7 – 16.0 calcination loss. The refractoriness of the clay is 1610 – 1750°C.

Based on the chemical composition, the plastic highly basic clay from this deposit could be recommended for testing at insulator works, but unfortunately the operation of this deposit is nearing an end.

Okladnevskoe deposit

This is located in Borovichi District, 29 km west from the town of Borovichi, and is connected by an automobile road with the town.

The clay occurs in a sheet bed extended from west to east with a surface area of 4.5 km^2 and thickness of 0.7 – 6.0 m (average thickness is 1.0 m), and the depth of occurrence is 12 – 30 m in the south-west and 50 – 73 m in the north-east.

The clay is represented by kaolinic, semi-kaolinic, and plastic varieties, but the latter occurs significantly less frequently.

The chemical composition of the clay (wt.% in calcined material) 11.33 – 47.64 ($Al_2O_3 + TiO_2$), 0.46 – 13.33 Fe_2O_3, 46.10 – 72.60 SiO_2, 4.20 – 24.00 calcination loss.

The clay reserves amount to around 22 million tons; 60 thousand tons are mined annually.

The clay from this deposit cannot be used in porcelain mixtures, since plastic varieties occur rarely and it is impossible to ensure their regular supply to consumers.

Malinovetskoe deposit

This is located in the Boroivichi District of the Novgorod Region, 35 km west from the town of Borovichi.

The workable deposit is sheet-like, nearly horizontal, of surface area 5.2 km^2, about 3.5 km long and 1 – 2 km wide. The seam occurs at a depth of 11 – 39 m (average depth — 27.6 m), and the average thickness of the seam is 2 m.

The clay seam is made up of three lithologic varieties: basic plastic, semi-kaolinic, and semi-acid. The reserves of plastic clay amount to 63.5%, those of semi-kaolinic constitute 18.6%, and semi-acid — 17.5%.

The clays have the kaolinite-hydromica mineral composition, and the plastic clay is highly disperse (the content of the fraction below 1 μm is over 60%).

The reserves of alkaline plastic clay constitute over 17 million tons. The capacity of the quarry is 450 thousand tons, and the reserves are sufficient for over 30 years.

Table 1 indicates the chemical composition of the plastic clays, and Table 2 show their ceramic properties.

In view of the total content of the colorant oxides, the clay from this deposit is not recommended for porcelain production.

Balakovskoe deposit

This is located in Lyubytinskoe District of the Novgorod Region, 6 km north-east from the Lyubytino railway station and 4 km north-east from Artem Mine No. 2. The deposit is situated 2 – 3 km from the Okulovka – Lyubytino – Nebolchi railway line.

In 1980 – 1984 the deposit was thoroughly explored with the aim of replacing the material sourced from the Artem deposit that was being exhausted.

The workable bed is a sheet-like body extended to 2 km in the north-eastern direction with a width of 0.6 – 1.1 km. The depth of the bed is 0.6 – 1.1 km and the width is 62.5 – 99.0 m, the thickness is 1.0 – 5.0 m (the average thickness 2.4 m).

The workable bed is composed of semi-kaolinic (86.2%), kaolinic (3.9%), and plastic (5.1%) clay of basic composition. The clay is moderately plastic, medium- and high-disperse, and mainly represented by kaolinite.

Table 3 lists the requirements imposed on plastic clays.

The deposit belongs to the group of prospected reserves and is not currently operating. The projected capacity of the quarry is 300 thousand tons of clay per year. The clay reserves of categories B + C1 comprise 6469 thousand tons, which ensures the operation of the quarry for 20 years.

Thus, the considered clays from the Borovichsko-Lyubytinskoe group of deposits cannot be used in porcelain mixtures for insulator production.

In 1994 – 1995 the Sevzapgeologiya State Company discovered rocks containing up to 1.5 – 2.0% Fe_2O_3 and 35 – 40% Al_2O_3 in the Sinenkovskoe and Povyshenskoe deposits of refractory clays in the eastern part of the Leningrad Region (North-Western Region of Russia). It was planned to continue the study of clay in these deposits in 1996 and to carry on prospecting in the vicinity of the Yavosemskoe bauxite deposit. However, due to a lack of funding, the work carried out by two companies (Sevzapgeologuiya State Company and Petersburg Geological Expedition) was suspended.

The deposits are located near a railway branch.

CENTRAL REGION OF RUSSIA

The Central Region of Russia has about 10 deposits of refractory clays; among those the Shulepovskoe, Latnenskoe, Ul'yanovskoe, and other deposits are currently operating.

Shulepovskoe deposit

This is located in the Mikhailovskii District of the Ryazan Region, 13 km south-west of Miloslavskoe settlement and railway station, 1.5 km east from the Zmeevka railway station.

The deposit was discovered in 1968. Detailed prospecting was carried out in 1985 – 1987. The refractory clay reserves in categories B + C comprise 184 thousand tons. The deposit is operated by a quarry belonging to the Skopinskii factory, which is the main consumer of clay.

The workable bed is a sheet-like body with an estimated thickness 2.7 – 7.6 m, on the average 4.8 m. The thickness of the overburden rock on the average is 7.5 m and varies from 5.2 to 9.8 m.

The applicability of this clay for producing ornamentals ceramic was evaluated;

– with respect to refractoriness, all clay samples are of the refractory class (1700°C);

– with respect to the content of ($Al_2O_3 + TiO_2$) in calcined state, the clay belongs to the basic group (33 – 35%);

– with respect to the degree of sintering, the clay has medium sinterability;

– with respect to the content of the colorant oxides, the content of colorant oxides is medium;

– with respect to plasticity (plasticity number is 11.0 – 13.2), it is moderately or highly plastic;

– with respect to the content of fine-disperse fractions, the clay is disperse (the content of particles below 1 μm is 55.14 – 56.74%);

– with respect to the mineral composition, the clay contains hydromica, kaolinite, occasionally with montmorillonite impurities.

The experiments performed by the Research and Development Institute of Decoration Industry demonstrated the possibility of making ceramic articles by casting in gypsum molds.

TABLE 4

Clay	Weight content in calcined material, %			Refractoriness, °C
	$Al_2O_3 + TiO_2$, at least	Fe_2O_3, at most	calcination loss, at most	
LT0	41.0	1.5	15.0	1730
LT1	39.0	1.5	18.0	1730
LT2	35.0	2.0	20.0	1690
LT3	30.0	2.5	20.0	1670

This clay is not recommended for use in porcelain mixtures.

Latnenskoe deposit

This is situated 25 km south-west from the city of Voronezh and occupies 20 km^2.

The refractory clay is represented by two large sheet beds, and the thickness of the clay varies from fractions of a meter to 8.4 m on the Pravoberezhnyi bed and up to 16.3 m on the Levoberezhnyi bed, the average thickness is equal to 2.8 and 2.7 m, respectively.

The refractory clays are divided into plastic, low-plastic, and carbonaceous varieties: plastic clay predominates. The mineral composition is mainly kaolinite, and the plastic clay is fine-disperse. Table 4 lists the requirements imposed on plastic base clays [3].

The deposit is operated by the Voronezh quarry administration, and the output is around 1000 thousand tons per year. The clay reserves are sufficient for 35 years (over 22 million tons). The company produces various refractory clays (LT0, LT1, LT2, LT3). These clays are used in the porcelain-and-faience industry to produce refractories.

Clays LT0 and LT1 can be recommended for testing in the production of insulators.

Ul'yanovskoe deposit

This is situated in the Ul'yanovskii District of the Kaluga Region, 110 km west from the city of Kaluga and 80 km south-west from the Suvorovskii Chamotte-firing Works.

The deposit has been comprehensively prospected. The roof of the deposit is studied as a raw material for brick, and the underlying refractory clay as a raw material for ceramics.

The workable body of refractory clay represents large nearly horizontal seams close to each other, of surface area 1.1 – 6.5 km^2. The length of the seams varies from 1.6 to 5.0 km and the width is 1.0 – 1.8 km. Altogether 11 seams have been prospected. The depth of occurrence of workable seams is 10.0 – 71.0 m, on the average 22 – 28 m. The seam thickness is 1.0 – 8.0 m.

The workable bed is represented by two main groups of clay: argillic and plastic. Each variety is further subdivided into basic and carbonaceous clays. The kaolinite clay contains 37 – 45% Al_2O_3 and up to 4.5% Fe_2O_3. The refractori-

TABLE 5

Clay*	Weight content, %			
	Al_2O_3	Fe_2O_3	TiO_2	calcination loss
TB-1	41.40	1.71	2.46	13.52
TB-2	38.16	1.71	1.76	12.54
TB-3	35.12	1.90	1.51	11.56
TB-4	31.44	1.91	1.51	10.88

* Refractoriness of all clays is 1730°C.

TABLE 6

Clay	Average weight content in calcined material, %			
	Al_2O_3	TiO_2	Fe_2O_3	calcination loss
BR-1	36.96	1.35	3.04	12.28
BR-1A, BR-2	36.71	1.38	3.30	11.83
BR-3	34.06	1.41	3.70	11.25
BR-4	31.03	1.50	4.12	10.27

ness of the clays varies from 1684 to 1790°C, and the prevailing level is 1730 – 1770°C.

The argillic clay sinters within the temperature interval of 1200 – 1600°C, the plastic clay in 1110 – 1400°C, and the carbonaceous clay sinters at 1100 – 1600°C. The technological properties of refractory clays are studied by the Institute of Refractories and encompass all lithologic varieties of clay.

Ten grades of clay are distinguished in the deposit; prevailing are highly-basic and basic grades (UO, UA 1, UP 1, UA 2, and UP 2), whose average quantity in the deposit comprises 50.6%. These clay grades are suitable for the production of refractory lining for steel casting.

The clay reserves in categories B + C1 comprise 51100 thousand tons, which provides for 68 years of operation of a mining company with an annual output of 500 thousand tons.

The deposit belongs to the group of prospected reserves and is not currently operating.

URAL REGION

The Ural Region contains 13 refractory clay deposits; out of that number the Troitsko-Boinovkoe, Belkinskoe, Nizhneuvel'skoe, and Berlinskoe deposits are currently operating [4].

Troitsko-Boinovskoe deposit

This is located on the east slope of the Middle Ural in the Bogdanovichi District of the Ekaterinburg Region, 20 km west from Bogdanovichi railway station and 17 km from the Bogdanovichskii Refractory Works, which is the main consumer of this raw material.

Seven beds are known in this deposit, four of which are totally exhausted.

The clay is mined on the second and third sites of the Poldnevskii bed in the amount of 510 thousand tons. The refractory clay reserves are around 40 million tons, which provides for 12 years of operation.

The mineral composition of the clays contains kaolinite (up to 95%) with an insignificant and variable impurity of hydromica or monothermite, heavy-fraction minerals, and quartz. The main parameters of the clay are listed in Table 5. The average content of Al_2O_3 in the first three grades is significantly higher than in the clay from the Veselovskoe deposit, and the refractoriness is high and sufficiently constant. The content of the colorant oxides is less than in the Veselovskoe clay (not greater than 2.5%).

Based on the degree of the sand content, clays are distinguished as rich, arenaceous, weakly arenaceous, and sandy. The rich clay in all parameters corresponds to grades TB-1 and TB-2, the arenaceous clay to grade TB-3, weakly arenaceous — to TB-4. The clay TB-1 is of medium dispersion, TB-2 and TB-3 are of low dispersion, and TB-4 is of coarse dispersion. The clay mainly has moderate or low plasticity.

Due to the elevated content of colorant oxides and insufficient dispersion, it is inadvisable to use clay from the Troitsko-Boinovskoe deposit in the production of insulators.

Berlinskoe deposit

This is situated in the Komsomol'skii District of the Kustanay Region and Troitskii and Chesmesnskii Districts of the Celiabinsk Region, 24 km west from Magnai railway station.

The deposit has been operated since 1971 by the Buskul'skii quarry, which is part of the mining and concentration division of the Magnitogorsk Metallurgical Works. The main consumers of this clay are the Magnitogorsk Works and the Chelyabinskii Works, and an insignificant amount of clay is supplied to the Ekaterinburg Ceramic Factory.

The workable bed is represented by white, gray, and dark gray refractory kaolinite clays of thickness ranging from 0 to 8 – 9 m. The clays form a large sheet 18 km long and 4 to 6 – 8 km wide. The average thickness of the clay in the bed is 4.5 m, and the maximum is 9.0 m. The average content of the main components in the clay is listed in Table 6.

The clay is characterized by a relatively high content of F_2O_3 (over 3%), and its refractoriness is 1580 – 1730°C. The clay has the kaolinite composition (40 – 70%) with a mica impurity (5 – 15%) and insignificant inclusions of talc, amphibole, and goethite-hydrogoethite. The clay has been comprehensively evaluated for the production of facing tiles, sewage pipes, and acid-resistant materials.

The clay from the Berlinskoe deposit is unsuitable for use in mixtures for high-voltage porcelain products.

Nizhne-Uvel'skoe deposit

This is situated in the Uvel'skii district 80 km south of Nizhne-Uvel'skaya railway station. The sheet bed extends to 7.3 km in the latitudinal direction. The clay is represented by

six lithologic varieties that differ in color and degree of sand content. There are interlayers and lenses of close-grained sand and arenaceous clay 0.3 – 2.0 m thick in the clay bed. The thickness of the clay varies from 0.5 to 8.0 m.

The chemical composition of the clay is heterogeneous, and the weight content of the components varies in the following limits (%): 18.0 – 41.0 ($Al_2O_3 + TiO_2$), 1.16 – 5.0 Fe_2O_3, 54.0 – 77.0 SiO_2. The moisture content is 20.0 – 39.0%, the air shrinkage 9 – 16%, and the refractoriness 1610 – 1730°C.

The deposit is operated by the Nizhne-Uvel'skii quarry mainly for the needs of metallurgical and refractory works in the Urals; 550 thousand tons are mined per year. The clay reserves comprise over 180 million tons. The quarry is provided with clay reserves for may years.

Due to the inhomogeneous chemical composition and the unstable technological parameters, clay from the Nizhne-Uverl'skoe deposit is not recommended for the production of insulators.

Kumakskoe deposit

This is situated in the Novoorskii District 2 km west from the Kumanskii railway station and 2 km south from Kumak settlement. The quarry is connected via a railway and an automobile road with the towns of Orsk and Novotroitsk.

The workable bed is represented by gray, light gray, white, and variegated clays of thickness 2.0 – 18.0 m [4]. The finely-disperse plastic clays of dark gray, gray, and white colors contain over 34% Al_2O_3, less than 2.5% Fe_2O_3, and belong to the basic clay of grade KU-1 (select).

The select clays are selectively mined in the quarry and mainly used by the Orsko-Khalilovskii Works.

The clay reserves in the deposit constitute around 25 million tons, and the yield of KU-1 grade is around 8%. The annual output of clay is 155 thousand tons.

Even select clay of KU-1 grade cannot be used in insulator production due to the high content of colorant oxides.

Nine deposits have been prospected and to some extent used in West and East Siberia and in the Far East. Of that number the following are operating: Omskoe (Novosibirsk Region), Troshkovskoe (Irkutsk Region), Kamenskoe (Buryatia), and Yukhta-Buzulinskoe (Amur Region). However, the majority of these clays contain an elevated amount of colorant oxides: more than 3%, except for some clays in the Troshkovskoe deposit.

Troshkovskoe deposit

This is situated in the Usolskii District of the Irkustk Region, near Polovina railway station. The surface area of refractory clays is 22 km^2, and 12 km^2 of them are prospected in detail.

Four sites are distinguished in this deposit: North-Western, Northern, Central, and Southern.

The refractory clays represent a sheet bed of nonuniform thickness. In the north and in the east the bed is fully outlined, whereas in other directions, clay occurs beyond the mapped area. The thickness of refractory clay on the North-Western and Northern sites varies from 1.0 to 21.0 m (on the average 3.5 – 4.0 m), and on the Central and South sites it ranges from 1.0 to 19.0 m (on the average 4.3 – 5.0 m).

TABLE 7

Clay	Requirements of TU-1512-003-45566673–99				
	weight content, %				refractoriness, °C, at least
	Al_2O_3, at least	Fe_2O_3, at most	TiO_2, at most	$Fe_2O_3 + TiO_2$, at most	
F0	32.0	0.9	0.6	1.3	1730
F1	30.0	1.2	0.6	1.6	1710

A special feature of this deposit is the existence of inclusions in the form of fine lenses of rubble sized 1.5 – 2.0 cm, rarely up to 10.0 cm. The occurrence of these rubble inclusions is random both horizontally and vertically. The average content of the rubble in clay is 12 – 16%.

The clay has the kaolinite composition, and is mainly classified as kaolinic clay. It is mostly basic clay colored white, gray, or dark gray to black, and occasionally exhibits red spots. After firing the clay acquires a white color. The clay belongs to the medium and moderately plastic groups.

The refractoriness of the clay is 1400 – 1800°C, and the bulk of the deposit has a refractoriness of 1640 – 1740°C.

The clay is mainly a high-quality material for porcelain production. The quality of clay used for porcelain is estimated with respect to the standard TU-1512-003-45566673–99 (Table 7). Clays of grades F0 and F1 with a coloring oxide content not greater than 1.8% are suitable for the production of household porcelain.

The refractory clay reserves constitute around 50 million tons, which is sufficient for 23 years of operation of the mining-and-concentration company. The deposit is operated by the Khaitinskii Porcelain Factory. The output is 40 thousand tons per year.

The central site is mined by the East-Siberian Refractory Works. Its output is 427 thousand tons per year. The company produces refractory products.

Clays from the Troshkovskoe deposit are recommended for testing at insulator factories.

The Katomskoe deposit of refractory clay has been prospected and is located 50 km from the Khaitinskii Porcelain Factory. This deposit belongs to prospected reserves. The registered clay reserves are 2877 thousand tons. In quality and technological parameters these clays are close to the Troshkovskoe deposit clay.

Thus, of the refractory clay deposits above considered, clay from the Latnenskoe and Troshkovskoe deposit can be recommended for use in the insulator industry. We deem it expedient to continue the evaluation of reserves of white-burning clay in the Leningrad Region in order to identify their chemical compositions and technological parameters

and determine the possibility of using these clays in porcelain mixtures, including mixtures for insulator production.

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